NASA-CR-200731

SRI International

Annual Report: March 1996
Covering the period 1 Febuary 1995 to 31 January 1996

DC-8 SCANNING LIDAR CHARACTERIZATION OF AIRCRAFT CONTRAILS AND CIRRUS CLOUDS

Prepared by:

Edward E. Uthe, Principal Scientist
Norman B. Nielsen, Senior Research Engineer
Geoscience and Engineering Center

Prepared for:

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, California 94035-1000

Attn: Ms. Estelle Condon
Mail Stop 245-20

SRI Project 6555

NASA Cooperative Agreement NCC 2-885

Approved:

James F. Vickrey, Director
Geoscience and Engineering Center

333 Ravenswood Avenue • Menlo Park, CA 94025-3493 • (415) 326-6200 • FAX: (415) 326-5512 • Telex: 334486

1 BACKGROUND AND OBJECTIVES

A Subsonic Assessment (SASS) element of the overall Atmospheric Effects of Aviation Project (AEAP) was initiated by NASA to assess the atmospheric impact of subsonic aircraft. As part of a competitive program described by the NASA Research Announcement NRA 94-0A-01, SRI International (SRI) was awarded a project to develop and test a scanning backscatter lidar for installation on the NASA DC-8 (year 1); participate in the Subsonic Aircraft: Contrail and Cloud Effects Special Study (SUCCESS) field program (year 2); and conduct a comprehensive analysis of field data (year 3).

As illustrated in Figure 1, a scanning mirror pod attached to the DC-8 aircraft will provide for scanning lidar observations ahead of the DC-8 and fixed-angle upward or downward observations. The lidar system installed within the DC-8 will transmit 275 mJ at 1.06 μm wavelength or about 130 mJ at 1.06 and 0.53 μm simultaneously. Range-resolved aerosol backscatter will be analyzed in terms of cloud/contrail spatial distributions and two-wavelength analysis of mean particle sizes.

The objectives of the project are as follows:

- Map contrail/cloud vertical distributions ahead of DC-8
- Provide DC-8 guidance into enhanced scattering layers
- Document DC-8 flight path intersection of contrail and cloud geometries
  - *In-situ* measurement positions relative to cloud/contrail shape
  - Extension of *in-situ* measurements into the vertical (integrated contrail/cloud properties)
- Analyze contrail/cloud radiative properties with LIRAD (combined lidar and radiometry) technique (we assume NASA will instrument the DC-8 with an upward-viewing narrow-beam infrared radiometer)
- Evaluate mean particle sizes of aircraft emissions from two-wavelength observations
- Study contrail/cloud interactions, diffusion, and mass decay/growth
- Make observations in the near-field of aircraft engine emissions.

The scanning mirror pod may also provide a scanning capability for other remote sensing instruments including the SRI ozone lidar and FTIR spectrometer.

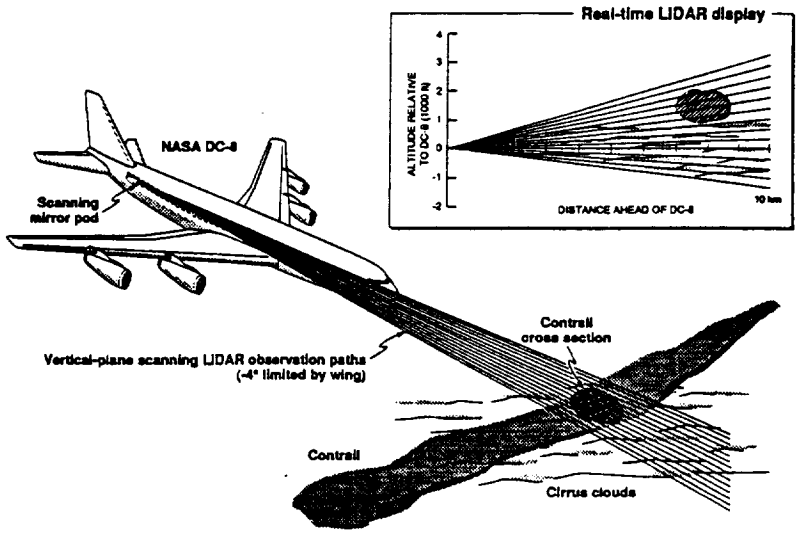


FIGURE 1 DC-8 Scanning Lidar Operation

2 YEAR ONE TECHNICAL STATUS

The first year effort has been directed to the design, construction, and testing of the DC-8 scanning lidar. SRI provided a preliminary design for the scanning mirror pod and NASA provided detailed design and construction of the pod. SRI also integrated lidar components on a standard DC-8 equipment rack, and developed software for control of the scanning mirror and for collection, recording, and display of lidar backscatter signatures. At the time of this report, installation of the lidar and mirror pod on the DC-8 was scheduled to proceed within a two-week period. The SUCCESS mission is scheduled for 8 April–10 May 1996.

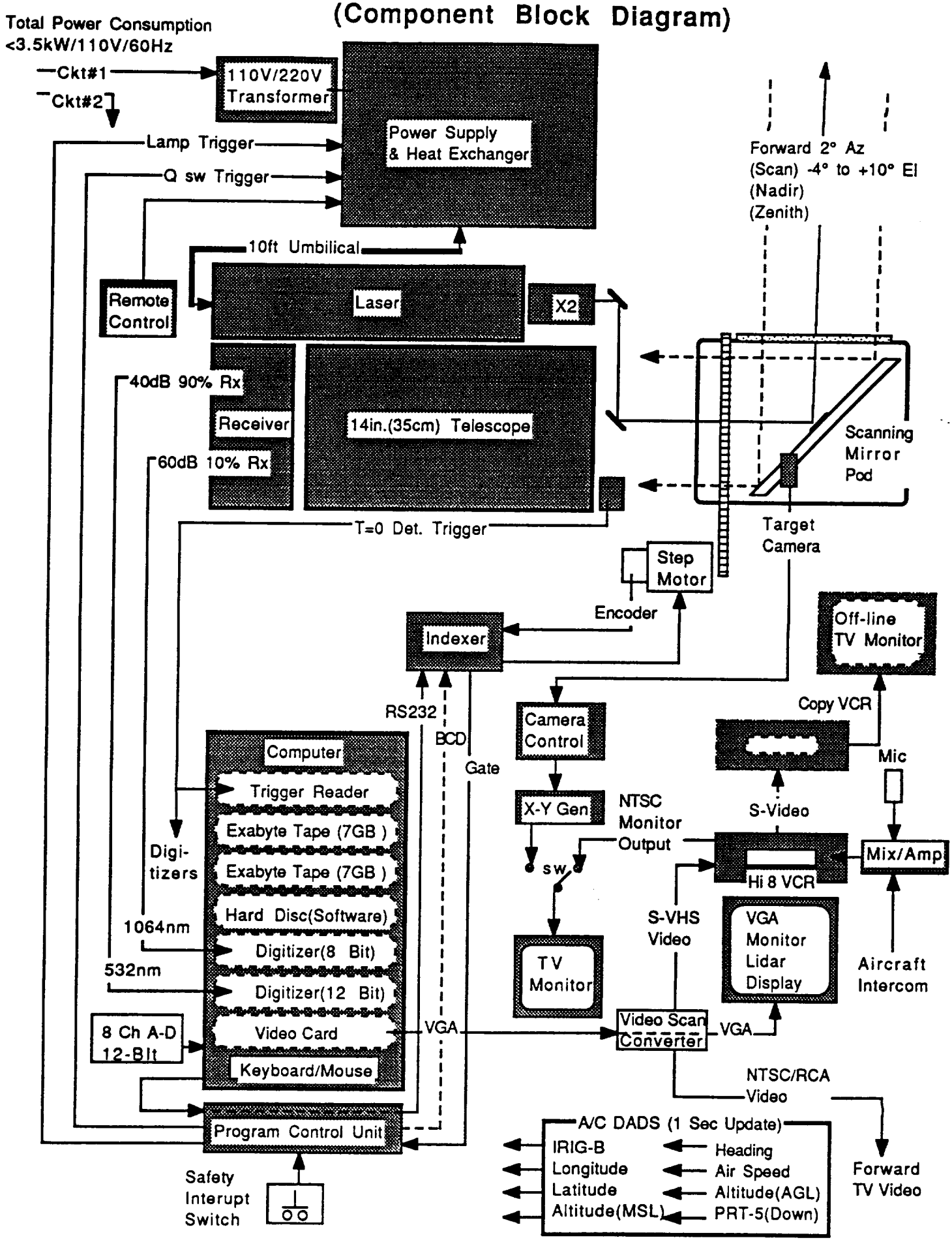
A component block diagram of the DC-8 scanning lidar is shown in Figure 2. The lidar can transmit energy at 0.53 μm and 1.06 μm wavelengths. Transmitted energy pulses are directed into the atmosphere at an angle determined by the scanning mirror that is controlled by a program unit. Position of the mirror is read by an encoder/indexer and is input to the lidar computer. Backscattered energy is collected by a 14-in. telescope and converted to electrical signals by the receiver detectors. The signals are digitized by 8-bit/100 MHz and 12-bit/60 MHz digitizers operating in single channel mode or at rates of 50 MHz and 30 MHz in dual-channel mode. Therefore the lidar signature can be processed in one to four channels. The computer records the data on dual 7 GB/8 mm Exabyte tape drives and then processes the data for real-time color-modulated display on a flat-face 14-in. VGA monitor. In addition, the VGA images are scan converted for recording in NTSC TV format on a HI-8 8 mm VCR. An off-line VCR and TV monitor will be used during the SUCCESS field program to view collected data in color-modulated pictorial form without need for computer processing. These video records can be used to select data files for case-study analysis using lidar signature digital records stored on 8 mm digital tape. Copies of the video tapes can be made during the field program for input to the SUCCESS database and for data exchange with other participants. Copies of the 8 mm Exabyte tapes can also be made for input to the SUCCESS database.

The NASA cost to construct the mirror pod did not include the mirror, window, and control motor. SRI requested that these parts be purchased with its first year funds and the equivalent labor costs displaced by these purchases be added to its second year funds to cover costs of the lidar preparation. This was necessary to obtain the needed components in a time frame consistent with the SUCCESS field program schedule. This request was approved by NASA. Unfortunately other factors not controlled by SRI or NASA led to schedule delays. Originally, the mirror pod was to be available for complete system checkout before installation on the DC-8. However, because of the schedule delays, this checkout is not possible and the lidar and pod will be installed on the aircraft just before the SUCCESS field program.

The other major effort of the year 1 project was the development of a safety operations plan. Laser eye safety calculations were made and these were used to develop an operations plan presented to NASA and FAA safety groups. After several revisions, the operations plan has been accepted in a form that should not greatly restrict use of the lidar during the SUCCESS program.

Dr. Edward Uthe attended the Virginia Beach 1995 annual meeting and presented the approach and objectives of the DC-8 scanning lidar project. He also participated in the SUCCESS planning meeting held at NASA Ames 29 August through 1 September 1995. A poster paper describing the DC-8 scanning lidar has been accepted for the 2nd Airborne Remote Sensing Conference and Exhibition (24–27 June 1996, San Francisco, California). An oral presentation describing the DC-8 scanning lidar has also been accepted for the 18th International

SRI DC-8 Lidar Configuration
(Component Block Diagram)



Laser Radar Conference (22–26 July 1996, Berlin, Germany). Conference proceeding papers will be submitted to NASA for release approval.

3 YEAR TWO EFFORT

SRI has received funds for the year 2 effort. Year 2 is directed to completion of the lidar integration on the DC-8 and operation during the SUCCESS field program. Funds remaining after the field program will be used to develop a database report and to copy video and digital tapes for input to the NASA database and for data transfer to other SUCCESS participants. In addition, a data reduction/analysis plan will be developed.

4 YEAR THREE EFFORT

The major SRI data reduction/analysis effort will be conducted after receiving year 3 funds. SRI will submit a request for these funds in FY97. We anticipate the development of a data reduction/analyses plan during interaction with SUCCESS participants during the data collection mission.